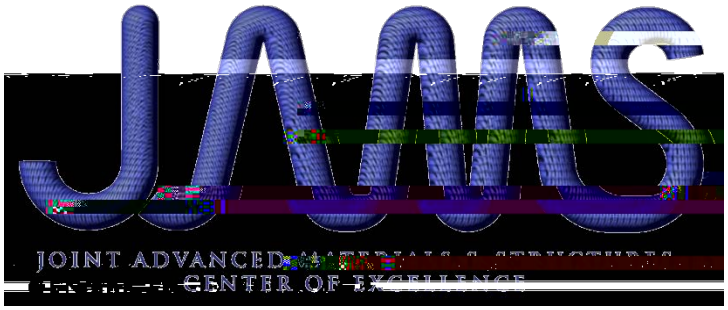

Effects of Moisture Diffusion in Sandwich Composites

2017 Technical Review

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University of Washington


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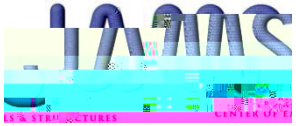


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Effects of Moisture Diffusion in Sandwich Composites

Motivation and Key Issues:

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    - Wicking of liquidous water through facesheet microcracks, along fiber/matrix interfaces, and/or through improper design of edge closeouts
    - Diffusion of water *molecules* through (otherwise undamaged) facesheets, resulting in increased core humidity levels


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Effects of Moisture Diffusion in Sandwich Composites

Overall Program Objectives

Effects of Moisture Diffusion in Sandwich Composites

- Principal Investigator
  - Mark Tuttle

- Students
  -

Effects of Moisture Diffusion in Sandwich Composites

Outline of Presentation

- Measurement of G_c associated with facesheet/core bond failures in sandwich structures:
  -

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  - Single-Cantilever Beam (SCB) test geometry/protocol under development by CMH-17 Task Group
  - Results obtained during 1st year of study (Sept '15-Sept '16)

  } Presented at Oct '16 AMTAS meeting

  - Expanded test matrix for 2nd year of study (ongoing)
- Design and fabrication of GAG specimens and test set-up (ongoing)

SCB Tests Conducted During 1st Year of Study

SCB specimens were machined from sandwich panels produced using 4-ply woven facesheets with $[45/0/0/45]_T$ stacking sequence and ½ in thick Nomex core:

Type	Manufacturer/Material Designation
Facesheet	Cytec T300/970 3k plain weave fabric
Core	Hexcel HRH-10 – 1/8 – 3.0 (0.50 in thick)
Adhesive	3M Scotcg.023 Tc 0.012 0J.nt0 Tc 0 Tw(10-0


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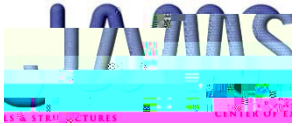


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SCB Tests Conducted During 1st Year of Study

- Cured facesheets and Nomex core were machined to size and stored for 2 months at 50ºC (122ºF) at 8% RH in a humidity chamber, to insure components were as “dry” as possible

SCB Tests Conducted During 1st Year of Study

- Six tests specimens were machined from the four “parent” panels (24 test specimens in total)

- Specimens produced from each panel were used for each Type, to avoid any potential manufacturing bias

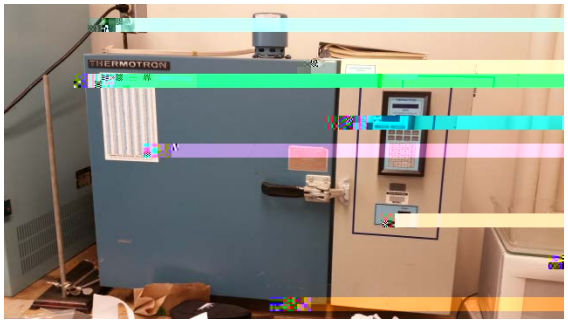
Type	Specimen Number					
A (as-produced)	1-1	2-2	3-3	4-4	1-5	2-6
B (thermally cycled)	2-1	3-2	4-3	1-4	2-5	3-6
C (humid)	3-1	4-2	1-3	2-4	3-5	4-6
D (humid&thermally Cycled)	4-1	1-2	2-3	3-4	4-5	1-6

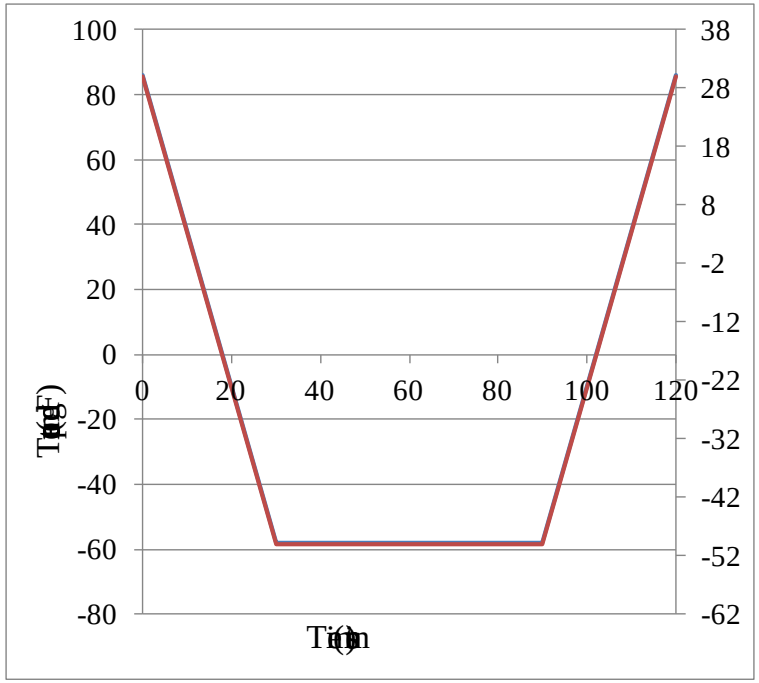
SCB Tests Conducted During 1

SCB Tests Conducted During 1st

SCB Tests Conducted During 1st Year of Study

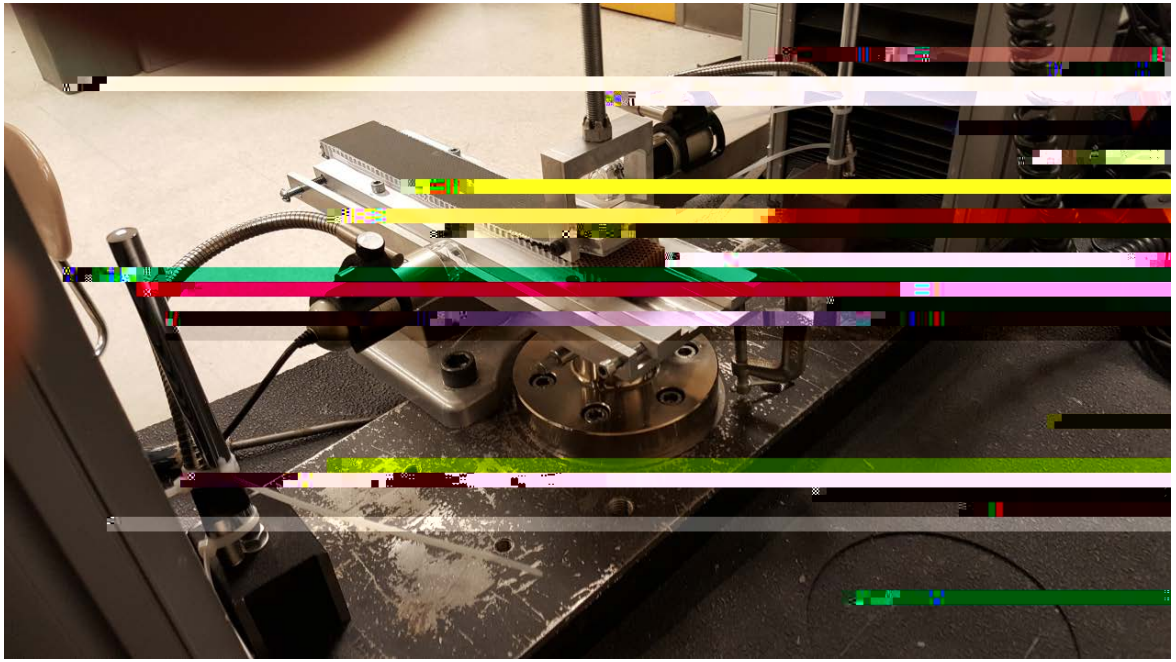
•All thermally-cycled specimens (Types B and D) were individually vacuum bagged (to insure constant moisture content in core volume) and subjected to 2-hr thermal cycles from 30º & <-50ºC





SCB Tests Conducted During 1st Year of Study

- The interfacial fracture toughness, G_c, was measured in accordance with the single-cantilever-beam (SCB) test standard being developed by a CMH-17 working group



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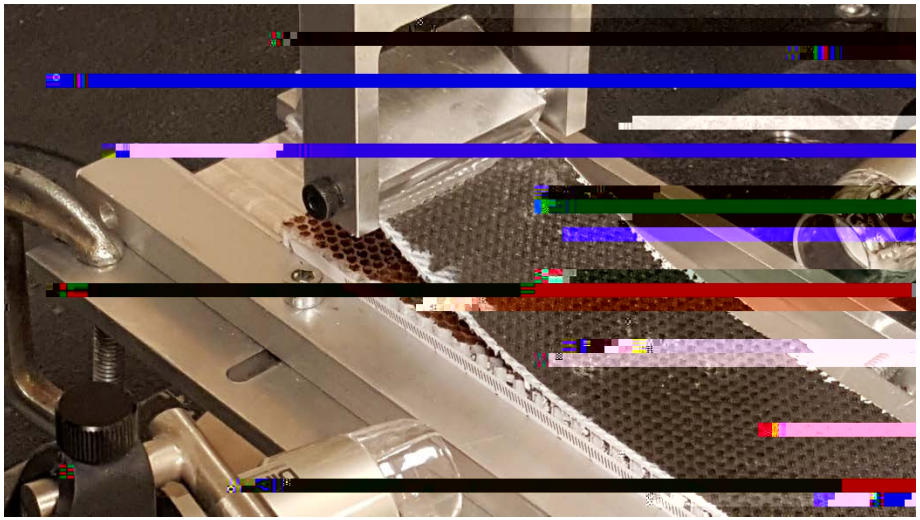
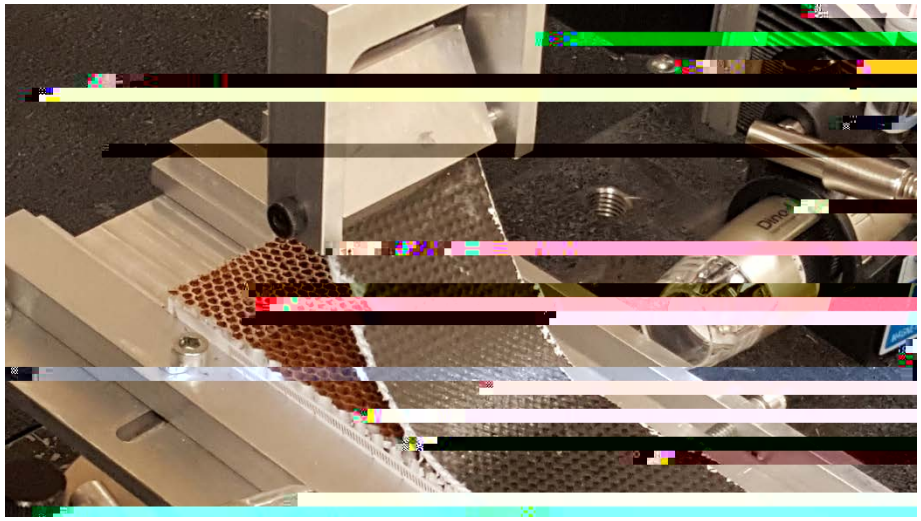


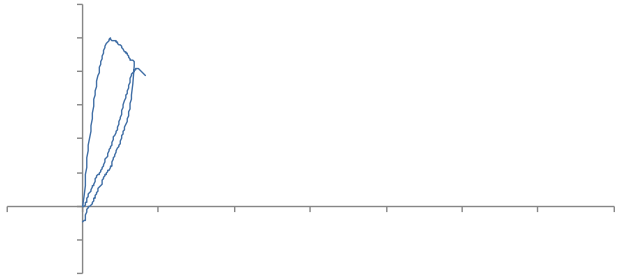


SCB Tests Conducted During 1st Year of Study

- A typical SCB test involves six load cycles

- Crack length is measured after each cycle

SCB Tests Conducted During 1st Year of Study

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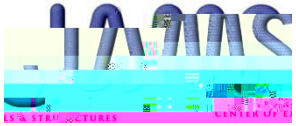


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SCB Tests Conducted During 1st Year of Study

SCB Tests Conducted During 1st Year of Study

Condition	Ave G_c (J/m^2)	StdDev G_c (J/m^2)	Average G_c, Normalized to Type A
Type A	1508	213	1.00
Type B	1410	214	0.94
Type C	1440	142	0.95
Type D	1368	198	0.91

SCB Tests Conducted During 1st Year of Study

Preliminary Conclusions

•Although significant scatter was evident, it appears that environmental factors (i.e., thermal cycling and/or elevated humidity levels) have a modest but measureable impact on interfacial fracture toughness, G_c,

•The most aggressive environmental conditions considered during this study (humid specimens exposed to 700 thermal cycles from RT to -50ºC) resulted in about a 10% reduction in average G_c.

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SCB Tests Planned for 2 nd Year of Study

Expanded Test Matrix:

Component	Description
Facesheet	Cytec T300/970 3k Plain Weave Fabric:
	$[45/0/0/45]_T$
	$[0/90/90/0]_T$
	$[0/45/0]_T$
	$[0/45/90/45]_s$
Core Materials	Hexcel HRH-10-1/8-3.0 (0.50 in thick)
	Hexcel HRH-10-1/8-3.0 (1.00 in thick)
	Hexcel HRH-10-1/8-8.0 (0.50 in thick)
	Hexcel HRH-36-1/8-3.0 (0.50 in thick)
Adhesive	3M Scotch-Weld Structural Film AF 163-2K

- Core materials recently received
- Test conditioning will be limited to “as produced” and “humid + thermally cycled”
- 18 “parent” panels being prepared (108 SCB specimens)

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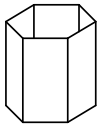
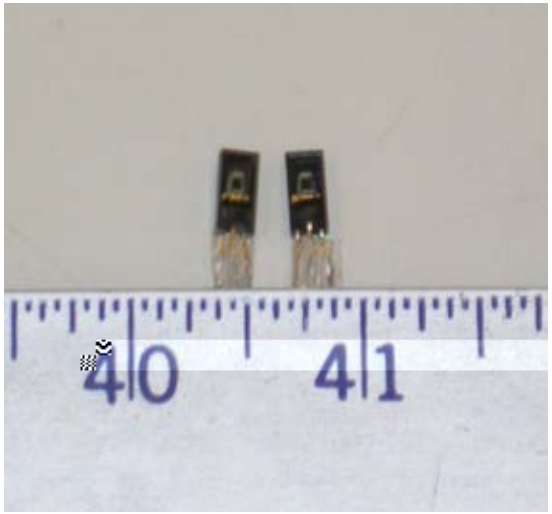
Design and Fabrication of GAG Specimen and Test Setup

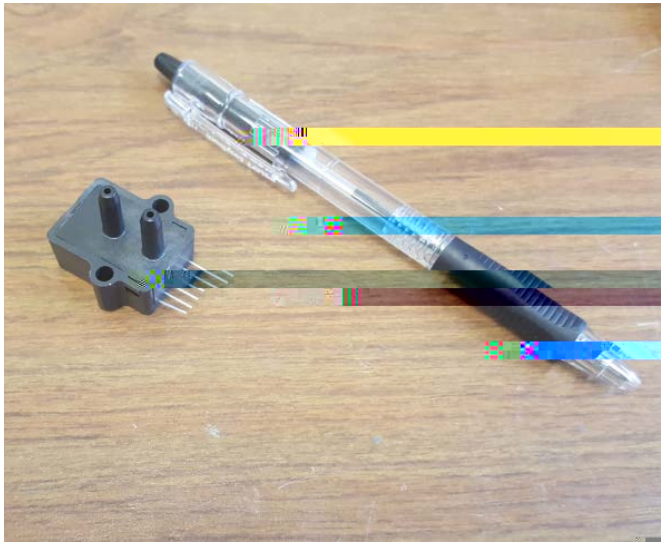
GAG Specimen:



Design and Fabrication of GAG Specimen and Test Setup

GAG specimens must use 1-in core, due to size of commercially-available pressure sensors





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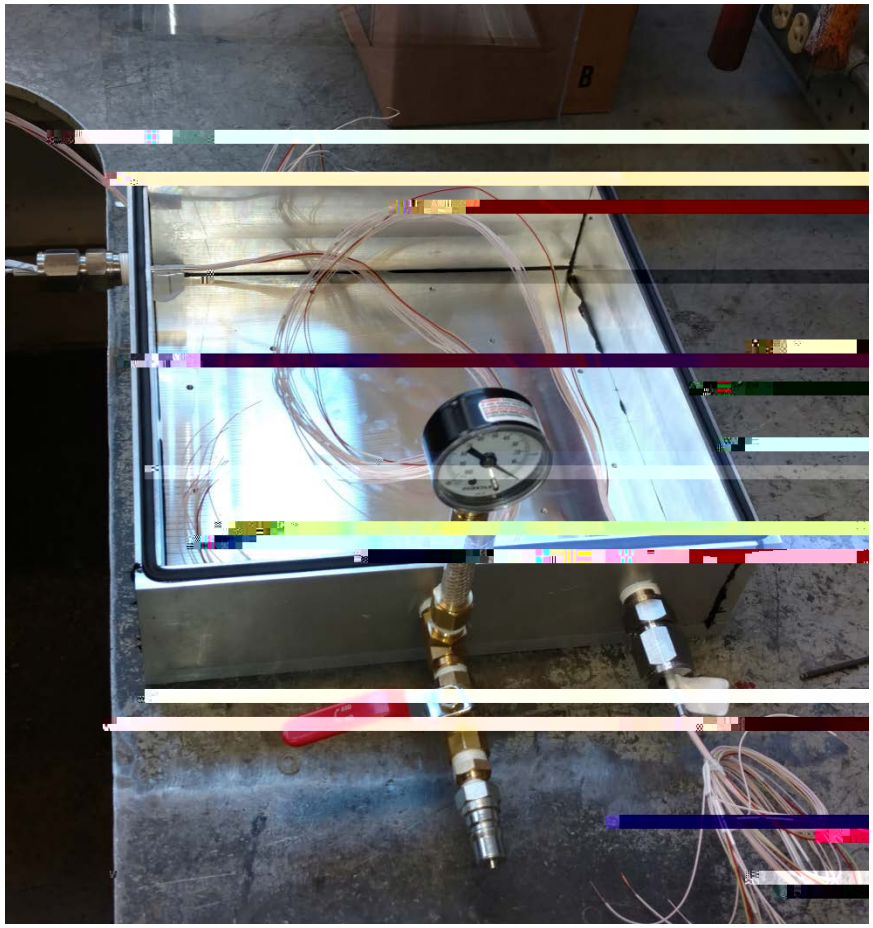

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Thank You!

Questions, Comments, Suggestions?

End of Presentation.

Thank you.